Retrieval of glaciological parameters from SAR data and mass balance modelling of glaciers in Northeast Greenland

During the last few decades, the Greenland Ice Sheet has experienced strong environmental changes. The most harsh and rapid of these changes have occurred particularly in the west and southeast of Greenland and have been well reported. The northeast of Greenland is yet to experience this transformation, which provides an excellent opportunity to track the changes to come. Therefore, this work aims at observing the evolution of outlet glaciers in the study area shown in Figure 1 by using high-resolution SAR data from the past and present.

Of scientific interest is the mass balance of glaciers that can be determined with the geodetic method or the mass budget method. The geodetic method uses the overall ice volume change to obtain the glacier mass balance, while the mass budget method determines the glacier surface mass balance and the dynamic mass loss from runoff and calving separately.

Fig. 1: The study area in Northeast Greenland with its main outlet glaciers and the Northeast Greenland Ice Stream (NEGIS).
Calving front location
For glaciers that are grounded at the front, the calving front location (CFL) is where the glacial ice breaks off into the ocean and is no longer physically connected to the ice sheet. This represents the gate through which ice losses for the mass budget method are measured.

A technique is developed to delineate automatically the CFL between given start- and end points only from SAR amplitude backscattering images. In contrast to other approaches, the algorithm requires no additional data like the ice flow direction. The method is able to map the glacier front also in crevassed conditions with ice melange and icebergs present in front of the glacier [Krieger 2017].

Geodetic mass balance
Based on time series of ice surface elevation this method allows the quantification of mass gains and losses of entire glacier systems and ice sheets. For converting volume into mass change, the density of the added or depleted volume is needed. The geodetic mass balance provides the potential sea-level rise of a certain glacier due to melting and ice discharge without additional knowledge about precipitation, surface melt and ice velocities.

For individual glaciers located in the NEGIS basin, the geometric extent of their catchments is derived from ice flow combined with elevation information from the TanDEM-X (TDM) global DEM. This allows restricting the calculation of the volume change to individual glaciers.

The spatially distributed surface elevation change from time series of TDM bistatic data of Zachariae Isstrøm and Nioghalvfjersfjorden over a period of 3 years was generated by differencing multiple TDM DEMs acquired in Dec/Jan 2010/11 and Dec/Jan 2013/14. An obvious thinning pattern larger than 10 m can be observed on the terminus of Zachariae Isstrom (Figure 2).

Fig. 2: The difference of mosaicked TDM (2013/14) and TDM (2010/11) elevations for Zachariae Isstrøm (east flowing) and Nioghalvfjersfjorden (north flowing). In the background is a RADARSAT-1 SAR amplitude mosaic from 2012-2013 [Joughin 2016].

References